

# 轮钟花属的恢复及其花粉和种皮证据\*

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## THE RESTORATION OF THE GENUS *CYCLOCODON* (*CAMPANULACEAE*) AND ITS EVIDENCE FROM POLLEN AND SEED-COAT

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**Abstract** The genus *Cyclocodon* Griff. was reduced by C. B. Clarke in 1881 into a section of the genus *Campanumoea*. Our LM and SEM observations on pollen morphology show that the pollen of all the three species in the former is 3-colporate with the exine sparsely high-spinulose, whereas that of the two species in the latter is 5~8-colpate with the exine relatively densely short-spinulose. SEM observations on seed-coat indicate that the primary ornamentation of the seed-coat of the two species in *Campanumoea* (*s. str.*) is characterized by regular and polygonal areoles which are much larger than the radial walls in diameter and by the bead-like secondary ornamentation on the radial walls, while that of the three species in *Cyclocodon* is characterized by irregular-shaped areoles which are nearly equal to the radial walls in diameter and by the rope-like secondary ornamentation on the radial walls. Thus, the pollen morphology is closely correlated with the seed-coat morphology. Taking the characteristics of pollen, seed-coat and gross morphology into consideration, the genus *Cyclocodon* is restored, separate from *Campanumoea* (*s. str.*). One new combination, *Cyclocodon celebicus* (Bl.) Hong, is made in the present paper. The genus *Cyclocodon* is considered closely related to *Platycodon* rather than to *Campanumoea*.

**Key words** Campanulaceae; *Campanumoea*; *Cyclocodon*; Pollen; Seed-coat; Taxonomical revision

*Cyclocodon* was established as a genus by Griffith in 1854 based on *C. adnatus*. Its status as genus separate from the genus *Campanumoea* Bl. was recognized by J. D. Hooker and Thomson in 1858 and Kurz in 1877. However, it was reduced to a section of the latter by C. B. Clarke (1881), *Campanumoea* Sect. *Cyclocodon* (Griff.) C. B. Clarke. This treatment had been retained till Hong (1995), who enumerated this entity as a separate genus. Murthy (1982) observed the distinctness in palynology between *Campanumoea* Sect. *Campanumoea* and Sect. *Cyclocodon*, thus treated the latter as a separate genus, but he used wrongly *Campanumoea* as its generic name.

Only viewed from gross morphology does Clarke's treatment seem reasonable, because the genus under discussion differs from *Campanumoea* only in climbing habit and calyx

\* We read Morris and Lammers' article "Circumscription of *Codonopsis* and the allied genera *Campanumoea* and *Lep-tocodon* (Campanulaceae: Campanuloideae). I. Palynological data" in Bot. Bull. Acad. Sin. 38: 277~284 (1997) after the revised version of the present paper had been submitted.

form. Nevertheless, their contrast in pollen morphology and seed-coat characters attracted our attention during a survey on palynology and seed-coat morphology of the Campanulaceae. The aim of the present paper is to report the results of observations on these two taxa and to discuss the taxonomical position of *Cyclocodon*.

## 1 Pollen Morphology

The material used in the present work is listed in Table 1. For observations under light microscopy(LM), pollen grains were hydrolyzed by acetic anhydride following Erdtman (1952), and for observations under scanning electron microscopy(SEM), pollen grains were first treated with warm water and then fixed in 75% ethanol, following Hong(1983). They were coated with gold before the observation under SEM Hitachi S-800.

Although pollen grains in all the materials were constant in shape, suboblate, they were distinctly different in aperture and slightly different in ornamentation. They are briefly described for each species examined.

Table 1 The material used for pollen observations

Taxa	Voucher specimens
<i>Campanumoea javanica</i> subsp. <i>japonica</i> (Makino) Hong	The Emei Mountain, Sichuan, China; Kuan, Li and Wang 1826(PE); the Fanjing Mountain, Guizhou, China; 2157 (PE)
<i>Campanumoea inflata</i> (Hook. f.) C. B. Clarke	Medog County, Xizang (Tibet), China; Ecological Exped. 11508 (PE)
<i>Campanumoea lancifolia</i> (Roxb.) Merr.	The Emei Mountain, Sichuan, China; Kuan, Li and Wang 1831(PE); Xinfong County, Guangdong, China, Den Lian 7896(PE)
<i>Campanumoea celebica</i> Bl.	Xizang (Tibet), China; s. collector 07211 (PE)

### 1.1 *Campanumoea javanica* subsp. *japonica* (Makino) Hong (Plate I : 1, 2)

Pollen grains shortly 4~6-colpate, mainly 5-colpate. They were described by Murthy (1982) as 5~(6)-zonocolpate. The exine short-striate and spinulose with spinules basally divided, closely and irregularly spaced and mostly less than 1  $\mu\text{m}$  high. Dunbar (1975) described the pollen of *C. maximowiczii* (= *C. javanica* ssp. *japonica*) as 5~6-colporate, but later corrected it to colpate following Avetisjan (1967) (Dunbar, 1984).

### 1.2 *Campanumoea inflata* (Hook. f.) C. B. Clarke (Plate I : 3~4)

Pollen grains shortly 5~8-colpate, but predominantly 6~7-colpate. The exine short-striate and spinulose with spinules basally divided, closely and irregularly spaced and less than 1  $\mu\text{m}$  high. Murthy (1982) also reported pollen grains of this species as 6~(7)-zonocolpate.

### 1.3 *Campanumoea lancifolia* (Roxb.) Merr. (Plate I : 5~6)

Pollen grains 3-colporate. The exine shortly striate and spinulose with spinules relatively few and large, basally divided, and mostly 2  $\mu\text{m}$  high.

### 1.4 *Campanumoea celebica* Bl. (Plate I : 7, 8)

Pollen grains 3-colporate, consistent with the report by Murphy (1982). The exine perforate and spinulose with spinules relatively few and large, basally divided, and mostly 2  $\mu\text{m}$  high.

According to Murphy (1982) and Avetisjan (1986), the pollen of *Campanumoea parviflora* is 3-colporate with the exine short-striate and high-spinulose, similar to that of *C.*

*lancifolia* and *C. celebica*.

From the above description, the pollen of all the five species in *Campanumoea* (*s. l.*, incl. *Cyclocodon*) can be grouped into two types. The one, represented by *C. inflata* and *C. javanica* in *Campanumoea* (*s. str.*), is multi-colpate, with relatively dense and low spinules on the exine surface, while the other, represented by the rest (all in *Cyclocodon*), is 3-colporate, with sparse and high spinules on the exine surface. Therefore, *Campanumoea* (*s. str.*) and *Cyclocodon* are distinctly different from the palynological point of view.

## 2 Seed-coat

The material used in the present work is listed in Table 2. Seeds were collected from herbarium specimens and coated with gold before observation under SEM Hitachi S-800.

Table 2 The material used for seed-coat observations

Taxa	Voucher specimens
<i>Campanumoea javanica</i> Bl. subsp. <i>javanica</i>	Lianxian, Guangdong, China: Tam Pui-Cheung 59973(PE)
<i>Campanumoea inflata</i> (Hook. f.) C. B. Clarke	Medog County, Xizang, China: B. S. Li & S. Z. Chen 1358(PE)
<i>Campanumoea lancifolia</i> (Roxb.) Merr.	Sichuan, China: Sichuan Exped. Tang Tsin 01136(PE)
<i>Campanumoea celebica</i> Bl.	Medog, Xizang: alt. 1700 m, 1974-08-20, Qinghai-Xizang Exped. 74-4430(PE)

### 2.1 *Campanumoea javanica* Bl. subsp. *japonica* (Makino) Hong (Plate II : 1, 2)

Seeds oblong. The primary ornamentation reticulate, with aureoles regular and polygonal in shape, and much larger than the radial walls in diameter. The secondary ornamentation on radial walls bead-ridged.

### 2.2 *Campanumoea inflata* (Hook. f.) C. B. Clarke (Plate II : 3, 4)

Seeds ovoid. The primary and secondary ornamentation similar to those in *C. javanica* subsp. *japonica*.

### 2.3 *Campanumoea lancifolia* (Roxb.) Merr. (Plate II : 5, 6)

Seeds ovoid. The primary ornamentation reticulate, with aureoles irregular in shape and nearly equal to the radial wall in diameter. The secondary ornamentation on radial walls rope-like.

### 2.4 *Campanumoea celebica* Bl. (Plate II : 7, 8)

Seeds nearly spheroidal. The primary and secondary ornamentations similar to those in *C. lancifolia*.

Haridasan and Mukherjee(1987) observed the seed-coat morphology of *C. inflata* and *C. parviflora*. According to their SEM photographs and description, the former is similar to *C. javanica*, while the latter similar to *C. lancifolia* and *C. celebica*.

Therefore, the seed-coat morphology of *Campanumoea* (*s. l.*) fall into two types. The one, found in *C. inflata* and *C. javanica*, both in *Campanumoea* (*s. str.*), is characterized by regular-shaped aureoles which are polygonal and much larger than the radial walls in diameter, whereas the other, found in all remaining three species, all in *Cyclocodon*, is characterized by irregular-shaped aureoles which are nearly equal to the radial walls in diameter and by the rope-like secondary ornamentation on the radial walls.

### 3 Discussion

From the above description, the pollen characteristics and seed-coat features are highly correlated with each other, which strongly supports the division of *Campanumoea* (s. l.) into two groups, i. e. *C. javanica* and *C. inflata* in one (= *Campanumoea* (s. str.)), and *C. lancifolia*, *C. celebica* and *C. parviflora* in the other (= *Cyclocodon*). Murthy (1982) also considered from his palynological study that these two groups were different at generic level. Furthermore, this division is also supported by gross morphology: *C. javanica* and *C. inflata* are both climbing herbs and their calyx-lobes are large, ovate-triangular or ovate-lanceolate, and entire. On the contrary, *C. lancifolia*, *C. celebica* and *C. parviflora* are erect herbs with calyx-lobes narrow, linear or linear-lanceolate and usually dentate. It is justifiable to recognize these two groups at generic level and thus to restore the generic status of *Cyclocodon*, separate from the genus *Campanumoea* (s. str.). Actually the first author of the present paper has already mentioned *Cyclocodon* as an independent genus (Hong, 1995). As implied by the palynological data, the genera *Cyclocodon* and *Campanumoea* are not closely related as generally considered. The baccate fruits in these two genera may well have come from convergence as a result of adaptation to the dispersal by animals. *Campanumoea* is closely related to the genus *Codonopsis*, while *Cyclocodon* may have a relatively close relationship with the genus *Platyodon*.

### 4 Taxonomical treatment

- A. Erect herbs; calyx lobes narrow, linear or linear-lanceolate, and usually dentate; seed-coat with areoles irregular, nearly equal to radial walls in diameter, and with rope-like secondary ornamentation on radial walls; pollen 3-colporate, with sparse spinules ca. 2  $\mu$ m high on the exine surface ..... **Cyclocodon** Griffith
- A. Climbing herbs; calyx lobes large, ovate-triangular or ovate-lanceolate, entire; seed-coat with areoles polygonal, much larger than radial walls in diameter, and with bead-like secondary ornamentation on radial walls; pollen shortly 4~8-colpate, with spinules closely and irregularly spaced and mostly less than 1  $\mu$ m high on the exine surface ..... **Campanumoea** Bl.

**Cyclocodon** Griffith, Not. Pl. As. 4: 279. 1854; Hook. f. et Thoms., Journ. Linn. Soc. Bot. 2: 18. 1858; Kurz, Journ. As. Soc. Beng. 46(2): 209. 1877.

**Typus generis** *Cyclocodon adnatus* Griff. (= *Cyclocodon lancifolius* (Roxb.) Kurz). According to this treatment one new combination should be made.

**Cyclocodon celebicus** (Bl.) Hong, comb. nov. — *Campanumoea celebica* Bl., Bijdr. 727. 1826. — *Codonopsis celebica* (Bl.) Miq., Fl. Ind. Bat. 2: 565. 1835. — *Codonopsis lancifolia* subsp. *celebica* Moeliono, in Fl. Males. ser. 1, 6: 121. 1960.

**Distribution** Myamar, Thailand to New Guinea, and China (Yunnan and southeastern Xizang).

**Cyclocodon lancifolius** (Roxb.) Kurz, Flora, 55: 303. 1872. — *Cyclocodon adnatus* Griff., Not. Pl. As. 4: 278. 1854. — *Cyclocodon truncatus* (Wall. ex A. DC.) Hook. f. et Thoms., Journ. Linn. Soc. Bot. 2: 18. 1858. — *Campanula lancifolia* Roxb., Fl. Ind. 1: 505. 1820. — *Codonopsis lancifolia* (Roxb.) Moeliono in Fl. Males. ser. 1. 6: 120. 1960. — *Codonopsis truncata* Wall., Cat. 1301. 1820, nom. nud.; A. DC., Monog. Camp. 120. 1830. — *Codonopsis albiflora* Griff., Not. Pl. As. 4: 279. 1854. — *Campanumoea lancifolia* (Roxb.) Merr., Enum. Philip. Pl. 3: 587.

1923.——*Campanumoea axillaris* Oliv., Hook. Icon. Pl. 3: 8, t. 1775. 1888.——*Campanumoea truncata* (Wall. ex A. DC.) Diels, Bot. Jahrb. Engler 29: 606. 1901.

**Distribution** China (south of the Yangtze River), Sikkim, Myamar, Cambodia, Vietnam, Indonesia and Philippines.

**Cyclocodon parviflorus** (Wall. ex A. DC.) Hook. f. et Thoms. Journ. Linn. Soc. Bot. 2: 18. 1858, excl. syn. *Campanumoea celebica* Bl.——*Codonopsis parviflora* Wall. Cat. 1300, 1820, nom. nud.; A. DC., Monogr. Camp. 123. 1830.——*Campanumoea parviflora* (Wass. ex A. DC.) Benth. et Hook. f. Gen. Pl. 2(2): 558. 1876.

**Distribution** Sikkim, Bhutan, eastern India, Myamar, Laos and China (Yunnan).

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## Explanation of plates

**Plate I** SEM photographs of pollen grains in *Campanumoea* (s. l.) 1 & 2. *C. javanica* subsp. *japonica* (Makino) Hong; 3 & 4. *C. inflata* (Hook. f.) Clarke; 5 & 6. *C. lancifolia* (Roxb.) Merr.; 7 & 8. *C. celebica* Bl. (1 & 5,  $\times 1500$ ; 3,  $\times 1749$ ; 4,  $\times 4380$ ; 7,  $\times 1800$ ; 2, 6 & 8,  $\times 4200$ )

**Plate II** SEM photographs of seed-coat in *Campanumoea* (s. l.) 1 & 2. *C. javanica* subsp. *javanica*; 3 & 4. *C. inflata* (Hook. f.) C. B. Clarke; 5 & 6. *C. lancifolia* (Roxb.) Merr.; 7 & 8. *C. celebica* Bl. (1,  $\times 48$ ; 3,  $\times 60$ ; 5,  $\times 100$ ; 4,  $\times 250$ ; 2 & 8,  $\times 480$ ; 6,  $\times 900$ ; 7,  $\times 120$ )

**摘要** 光学显微镜和扫描电镜观察表明,金钱豹属(广义)花粉明显分为两个类型:*Campanumoea inflata* 和 *C. javanica* subsp. *japonica* 的花粉 5~8 沟,外壁具相对密的短刺,刺高不过 1  $\mu\text{m}$ ,而 *C. lancifolia*, *C. celebica* 和 *C. parviflora* 的花粉 3 孔沟,外壁刺稀疏,高于 2  $\mu\text{m}$ 。种子表面纹饰也同样可分为两类,前两个种一类,其种子表面网状,网眼规则而多角形,直径大于网脊宽度,网脊上的次级纹饰为念珠状,而后三种为一类,其种子表面网眼不规则,直径与网脊宽度近相等,网脊上的次级纹饰绳索状。可见花粉特征与种皮性状是高度相关的。后三个种所属的分类群就是被归并了的属 *Cyclocodon* Griffith. 综合花粉、种皮及外部形态,这个属应予恢复。其近缘属应是 *Platycodon*, 而不是 *Campanumoea*。

**关键词** 桔梗科;金钱豹属;轮钟花属;花粉;种皮;分类修订



